Purpose of this Guide

This document is the WaveDump user's manual; it contains informations for the installation, the complete command list explained and the syntax of the configuration file.

Change Document Record

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14 April 2011	04	Revised all chapters, new document format.
01 March 2012	05	Revised § 1
07 June 2012	06	Updated §System requirements & installation setup

Symbols, abbreviated terms and notation

ADC	Analog to Digital Converter
DPP	Digital Pulse Processing
FFT	Fast Fourier Transform
FSR	Full Scale Range
SBC	Single Board Computer

Reference Document

[RD1]   User Manual UM1935 - CAENComm User & Reference Manual

[RD2]   Application Note AN2472 - CONET1 to CONET2 migration

[RD3]   Guide G2483 - WaveDump QuickStart Guide

CAEN Electronic Instrumentation

Index

List of Figures

List of Tables

CAEN Electronic Instrumentation

1 Introduction

This document is the WaveDump user's manual; it contains informations for the installation, the complete command list explained and the syntax of the configuration file. For a practical first use example, refer to WaveDump QuickStart Guide.

WaveDump is a C based console application that can control any model of CAEN digitizer and it must be considered as a starting point in order to create an own acquisition software: it is an example of the use of the *CAENDigitizer* library to control the data acquisition by CAEN digitizers.

To avoid any misunderstanding, we remind you that *WaveDump* is a demo tool developed only for CAEN digitizers running <u>standard firmware</u>; if your digitizer runs some DPP firmware (e.g *DPP PHA*, *DPP CI* or *DPP-PSD*) you have to use the related *DPP Control Software* that you may download from CAEN website.

System requirements & installation setup

OS	OS version	CAEN Library required	Third-party software required
Windows	2000/XP/Vista/7 (32 and 64-bit)	CAENDigitizer CAENComm CAENVMELib[(1)]	n/a
Linux	kernel Rel. 2.4/2.6 (32 and 64-bit)	CAENDigitizer CAENComm (rel. 1.0 or later) CAENVMELib	Gnuplot

[(1)] *CAEN libraries are locally installed by the WaveDump Installer.*

Tab. 1: host PC requirements

First of all be sure to have all the third-party software listed in the Tab. 1 installed, then:

- go to WaveDump web page: Home / Products / Firmware/Software / Software Tools / Digitizer Tools / CAEN WaveDump.

- Download the WaveDump software package related to your OS in the "Download" tab.

- Uncompress the downloaded package.

- **For Windows users:** launch the WaveDump Setup executable file and follow the installer instructions.

Note: WaveDump for Windows OS is a standalone version which installs locally all the required libraries (see **Tab. 1**) and doesn't need them to be installed apart by the user.

- **For Linux users:** before to install the CAENUpgrader, the installation of the CAEN required libraries is needed. Click on the red link above the CAENUpgrader package in order to download them.

Fig. 1.1: Additional CAEN libraries required by Wavedump to be installed apart in Linux environment

Install the required libraries starting with CAENVMELib, then CAENComm, finally CAENDigitizer. Now, install WaveDump following the instructions in the INSTALL file.

Once installed, the WaveDump folder generated on the host PC typically contains source files, include files, Windows project files, Lib files for development for x86 and x64, executable files, precompiled and custom-developed (see the README file).

CAEN ![n] Electronic Instrumentation

2 Board Connection

CAEN digitizers can be connected to the host PC through the three following ways.

Direct Link to the Module via USB

Desktop and NIM versions can be directly handled via USB, just connecting the digitizer to the host PC via the USB cable (the USB driver is available on Digitizer web page).

Direct Link to the Module via Optical Link

Every CAEN digitizer can be controlled directly via Optical Link; for this purpose a CAEN PCI or PCIe controller (Mod. A2818 and A3818) is required. See the web pages of A2818/A3818 for more info.

In this case the unit must be connected to the featured controller via the optical fibre cable (see the Ordering Options of the controller).

Link through a VME Bridge

VME Digitizer Boards can be controlled via VMEbus through a VME Bridge.

Two CAEN bridges are available:

V1718 / VX1718 with USB interface (requiring just a host PC with a free USB port)	V2718 / VX2718 with Optical Link (requiring Mod. A3818 or A2818 controller)

Tab. 2: CAEN Bridges

✎ **Note:** If you want to use a VME bridge from another manufacturer or a SBC you have to provide a CAENComm-like library. Please refer to the Application Notes AN2472 [RD2].

CAEN Electronic Instrumentation

3 WaveDump Overview

WaveDump is a C console application that allows to manage data acquisition with all models of the CAEN digitizer family with Standard Firmware.

WaveDump allows to:

- Open the connection with the digitizer through a physical channel (USB, Optical Link and VME).

- Read and view information about the card (model, serial number, FW revision, etc ...).

- Program the digitizer according to parameters written in a configuration file (text file).

- Start and stop the acquisition (run on / off).

- Send, on command, software trigger (single shot or continuous).

- Read the event data and display the data throughput rate (MB/s) and the trigger rate. The readout can take place with or without the use of interrupts.

- Perform some simple data analysis (post processing) such as the signal FFT and the histogram of the samples.

- Save the waveforms (sequence of samples) to ascii or binary output files; the writing can be 'one shot' or continuous (recording of a sequence of events).

- Plot, using an external graphical tool (gnuplot), the acquired waveform, or the FFT of the selected channels histogram.

WaveDump is based on *CAENdigitizer* and *CAENcomm* libraries; the latter manages communications at a low level (read/write) for all types of physical channel. The following block diagram shows the structure of *WaveDump* with its libraries and file input and output.

Fig. 3.1: CAEN WaveDump software architecture

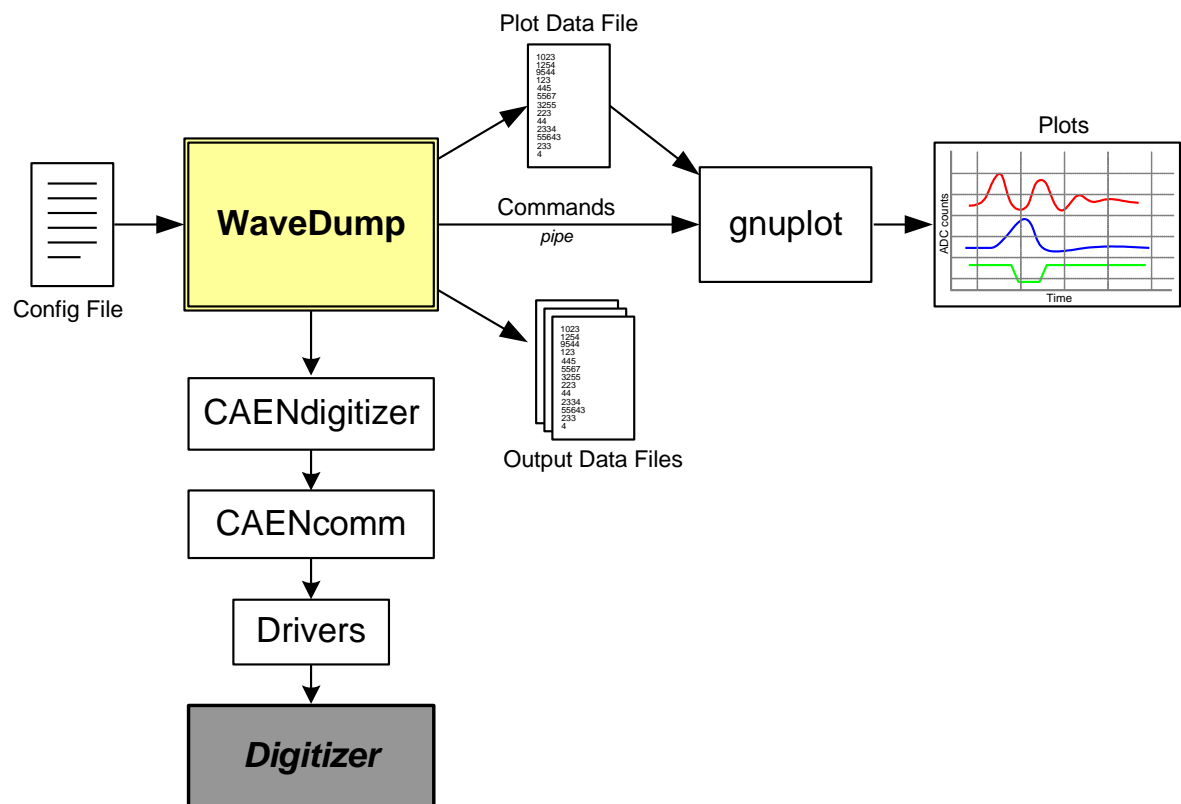It should be noted that, in case of access to the digitizer via the VME bus, the *CAENcomm* manages only CAEN VME bridges (V1718 and V2718); if the user wishes to use a third part bridge or SBC, it is necessary to provide a CAENcomm equivalent library (wrapper), in which the functions for the bus access are compatible with the used system. For more details, refer to the CAENComm manual [RD1].

The source code of *WaveDump* shows the sequence of steps to do in order to program the digitizer and manage the data acquisition. *WaveDump* is a practical example of the use of *CAENdigitizer* library and the relevant functions; therefore, it represents the starting point for the user who needs to develop its own acquisition application.

Since *WaveDump* is capable of handling all types of digitizer, some parts of the code may be redundant because they have to foresee various cases; the user who wants to use a particular digitizer can remove all those pieces of code that are not of interest. In case of digitizer with channels divided in groups (series x740), to simplify the use of *WaveDump*, you can only plot the 8 channels of one group, although the acquisition (and save the output file) manages all channels simultaneously.

Beyond the readout, plot and save of row data, *WaveDump* presents also some simple examples of data analysis (FFT and histogram); starting from them, the user can easily develop his own post-processing algorithms.

WaveDump is written in C and does not use graphics internally, so it is portable to any platform; the code is compatible with Windows and Linux.

The configuration file, by default ***WaveDumpConfig.txt***, contains a list of parameters; the installation directory includes a typical configuration file that contains all possible parameters preceded by some comments which briefly explains their use. For more details, see section § 2. The user can edit the configuration file or create a GUI that allows to set the parameters through a control panel and then generates the configuration file.

As mentioned, in order to plot the data, *WaveDump* relies on an external program (namely ***Gnuplot***); data for the plot are written to file, while the plot commands are passed from *WaveDump* to *Gnuplot* through a pipe. All functions related to the plotting are contained in a source file separated from *WaveDump*; the user can replace the calls to *Gnuplot* in order to use other tools. *Gnuplot* (version 4.2) is automatically copied to the proper working directory during the installation of *WaveDump* (only for Windows installation). Linux users have to install *Gnuplot*.

On-line Commands

Once started (following the instructions in the Quick Start Guide [RD3]), *WaveDump* parses the configuration file; if a formal error occurs, it is displayed in the shell.

It is also possible that the parameters and commands are formally correct but some of them are not valid for that type of digitizer; this is indicated when programming the digitizer by a warning message. Although this may not affect the operation of *WaveDump*, the command that caused the error shall be found and the wrong value corrected.

Once programmed the digitizer, *WaveDump* waits for the start of the acquisition ('**s**' key). While acquisition is running, *WaveDump* accepts some on-line commands associated with particular keys.

They are:

Key	Function
s	Start / Stop acquisition
q	Quit WaveDump
R	WaveDump restart, this command allows you to reload the configuration file and restart with a new acquisition
t	Sends a software trigger (single shot), this command is especially useful when the card has no data (no trigger) because it forces the acquisition of an event. In analogy with the oscilloscope, we could say that this command is the "Force trigger" button
T	Enables / disables the continuous generation of software trigger: inside the acquisition loop, the program sends a trigger, reads the corresponding event and executes data analysis. It is like the "Auto trigger" in oscilloscopes.
p	Plot the traces of channel for enabled for plotting (which does not necessarily coincide with the n channels enabled for acquisition), the plot is single shot.

P	Enable / Disable the plot to continuous plot activated channels
w	Save to disk a single event, writing a file for each enabled channel, named wave_n.txt, where n is the channel number. Warning: the files are overwritten each time. Each file can be ASCII or binary and may contain a header or not, depending on the settings assigned in the configuration file.
W	Enable / Disable the continuous events saving to file. As before, it creates a file per channel, the only difference is that the W option allows to write the file in append mode, Attention: the file size can grow very quickly
0 .. 7	Insert / remove the channel n (n = 0 .. 7) from the plot (if such a channel is enabled) in the case of Model x740, n refers to the channel within the currently active group, e.g. , if it's on group 2 (channels 16 to 23), press 3 you insert / remove the channel 19.
g	Switch to the next group of 8 channels (only in the Mod x740 series). NOTE: The active group refers only to the plot (in fact, the plotter can handle only 8-track), while the acquisition is always enabled on all groups.
f	Toggle from waveform plot to FFT plot.
h	Toggle from plot to plot histograms of waveform.
[Space]	Displays the online help

Tab. 3: WaveDump on-line commands

Inside the *Gnuplot* window, there are active bindkeys and functions associated to the mouse:

Key	Function
a	Autoscale to be x-axis and y
r	Enable / Disable ruler
g	Enable / Disable grid
y	Set the scale y at full scale for the specific digitizer (scale x remains unchanged)
p	Return to previous zoom

Tab. 4: Gnuplot window commands

Zoom Area: right click on one corner of the area, release the button, left click on the opposite corner.

Click with the right button on the window bar in order to open a menu that allows to make the print, copy the screen-shot to the clipboard, change colours, etc...

4 Sintax of the configuration file

The configuration file is divided into two parts: **common settings**, indicated in the `[COMMON]` section and **individual settings** for individual channels (or groups in the case of *Mod. x740 series*) indicated in the `[n]` section, where n is the number of channel (or group).

The common settings are the ones common to all the channels of the digitizer, the individual settings are the ones related to a single channel of the digitizer. Please note that some settings in the common section can be overwritten by the corresponding settings in the individual section.

The individual setting can be made also in the common settings: in this case they are applied to all channels.

Note: the special commands `@ON` and `@OFF` allows to skip entire blocks of lines: in fact the WaveDump command parser, when reading the command `@OFF` from the configuration file, ignores all subsequent commands until it reads the command `@ON`.

Common Settings

OPEN `LinkType LinkNumber NodeNumber BaseAddress`

Specifies the path of the physical channel to open communication with the digitizer:

`LinkType`	Identifies the type of channel and can be **USB** or **PCI**. USB is a direct connection from PC to digitizer (Desktop models or NIM) and the connection through V1718 and VME bus (VME models). PCI is a direct connection from PC A2818 (PCI controller) a digitizer through fiber optics (all models) and connection through V2718 and VME bus (VME models).
`LinkNumber`	The number of the connection. Typically is **0** (only one digitizer connection to the PC). In case of more digitizers connected, although WaveDump can handle only a digitizer, it is necessary to specify which has to be accessed. LinkNumber identifies which USB or A2818 is in use, but unfortunately in advance it's unknown which LinkNumber corresponds to which USB port or PCI slot.
`NodeNumber`	This parameter must be specified only when connected via optical link (PCI) and indicates the node in the daisy chain. Typically is **0** (only one digitizer in the optical chain), it may be different if more than one digitizer (or V2718) is connected in a daisy chain. .
`BaseAddress`	Indicates the Base Address (32-bit hexadecimal number) to access the digitizer via the VME bus. This number should be 0 for the direct connections from PC to digitizer.

GNUPLOT_PATH `"path"`

Path to *Gnuplot* executable file; for Windows installation, it is normally `".\"` because gnuplot is copied into the working directory.

OUTPUT_FILE_FORMAT `option`

`Binary` or `ASCII`. Indicates the type of output file. In case of binary file, each sample takes one byte for x721 and x731 series and one short (2 bytes) for all other models.

OUTPUT_FILE_HEADER `option`

Where `option` can be `YES` or `NO`. It determines whether the output file must contain a header or not for each event.

RECORD_LENGHT `Ns`

Indicates the number `Ns` of samples to be acquired for each trigger (acquisition window). Note: Due to the constraints due to the granularity of this setting, it is possible that the actual number of samples is approximated to a value slightly different from that set. The maximum value of `Ns` depends on the memory size that varies from model to model (see specifications); for x742 family the options available are only `1024, 520, 256` and `136`.

CAEN ⬡ Electronic Instrumentation

TEST_PATTERN `option`

Where `option` can be `YES` or `NO`. If enabled, the data from ADC are replaced by an internal test pattern, that is a triangular wave ranging from 0 to full scale.

ENABLE_DES_MODE `option`

Where `option` can be `YES` or `NO`. This setting applies to series x731 and x751 and is ignored for others. It enables Dual Edge Sampling mode, that is the interleaving of two channels to double the sampling frequency of the digitizer (i.e. 1GSps for x731 and 2GSps for x751). When DES_MODE is enabled, only half of the channels will be enabled (even for x731 and odd for x751), regardless the input enable setting in the configuration file.

EXTERNAL_TRIGGER `option`

This command decides how the External Trigger is used; there are three options:

`ACQUISITION_ONLY`: the arrival of a trigger on the front panel causes the acquisition of one event in all the channels of the board.

`ACQUISITION_AND_TRGOUT`: the same as before but, in addition, the external trigger is also propagated to the TRG-OUT (or GPO for the Desktop and NIM versions) connector.

`DISABLED`: the external trigger is ignored.

FAST_TRIGGER `option`

Where `option` can be `DISABLED` or `ACQUISITION_ONLY`. <u>This setting is only for x742 digitizers</u>. When enabled, the fast trigger inputs (TR0, TR1) are used for data acquisition.

FAST_TRIGGER_DIGITIZING `option`

Where option can be `YES` or `NO`. <u>This setting is only for x742 digitizers.</u> If enabled, the fast trigger signal is digitized and it is present in data readout as channel n.8 for each group.

MAX_NUM_EVENTS_BLT `Ne`

Indicates the maximum number of events that can be transferred in a block transfer. It ranges from `1` to `1023`. High values of the parameter correspond to high readout bandwidth, but require more memory allocated for the block transfer.

POST_TRIGGER `value`

Where value is a number ranging from `0` to `100`; it indicates the size of the post-trigger in percent of the record length. On models x742 there is a delay of about 35ns on signal Fast Trigger TR; the post trigger is added to this delay.

TRIGGER_EDGE `option`

Where option can be `RISING` or `FALLING`. It determines whether the channel auto-trigger is asserted on the rising edge or falling edge. NOTE: This setting must be COMMON to all channels.

USE_INTERRUPT `value`

This option decides if the readout is done in polling mode or using the interrupts. If `value = 0`, interrupts are disabled (polling mode). In this case, WaveDump continuously reads the digitizer to know if there are data. If `value = N`, with `N> 0` and `N <1024`, the reading process enters a passive wait status until it receives an interrupt from the digitizer (from VME or optical link) or the timeout is reached. The arrival of the interrupt request indicates the presence of at least N events in memory. When the process is awakened by the interrupt, it reads a block of data; although not necessary, it is logical to set the parameters INTERRUPT and BLT_NUM_BLOCK at the same value. There are other related parameters (such as Rora or Roak release mode, the interrupt level on the VME bus, the time-out, etc ...) that are permanently assigned by some *#define* in the C source code; users can change these parameters according to their needs.

NOTE: interrupts can not be used to read via USB.

FPIO_LEVEL `option`

Where option can be `TTL` or `NIM`. It indicates the electrical level for the front panel LEMO I/Os (TRG_IN, TRG_OUT and S_IN for VME; TRG_IN, GPI and GPO for Desktop and NIM).

WRITE_REGISTER `address data`

Where `address` is the address offset of the register (16 bit hex) and `data` is the value being written (31 bit hex).

This command allows the user to have a direct write access to the registers of the board. **NOTE:** all the direct write accesses are executed before the other settings, thus it might happen that one specific setting overwrites the register content.

Individual Settings

ENABLE_INPUT `option`

Where option can be `YES` or `NO`. This command enables or disables a channel for the acquisition. NOTE: for the series x740 and x742, this setting refers to the group of 8 channels: all channels belonging to the group are enabled/disabled at the same time. NOTE: *WaveDump*, depending on the type of digitizer and DES_MODE (channel interleaving) setting, automatically disables the channels that are not present, regardless of this setting.

DC_OFFSET `value`

Where `value` is a float that indicates (in percent) how much the input dynamics is shifted compared to the dynamics centered on zero (i.e. from -FSR / 2 to +FSR / 2, where FSR is the full scale range, for example 2 Vpp for x720); value ranges from -50 to **50**. For x740 and x742 series the DC offset is the same for all channels in the group. For x742 series the DC_OFFSET range is bigger than other; see the next

Setting DC_OFFSET to -50, the dynamics of the signal will be from -FSR to 0 (completely negative signal), setting to 50, the dynamics ranges from 0 to FSR (completely positive signal); setting to 0, the signal is bipolar.

GRP_CH_DC_OFFSET `dc_0, dc_1, dc_2, dc_3, dc_4, dc_5, dc_6, dc_7`

This setting is only for x742 digitizers and it can be used to set different DC offset values for each channel in the group. `dc_0 .. dc_n` values are floats that indicates (in percent) how much the input dynamics is shifted compared to the dynamics centered on zero (i.e. from -FSR to +FSR, where FSR is the full scale range); value ranges from -50 to 50.

Setting DC_OFFSET to -50, the dynamics of the signal will be from -3FSR/2 to -FSR/2 (maximum negative signal), setting to 50, the dynamics ranges from +FSR/2 to +3FSR/2 (maximum positive signal); setting to 0, the signal is bipolar.

TRIGGER_THRESHOLD `value`

Set the trigger threshold (in ADC counts) for the generation of self-trigger channel. `value` can range from 0 to 2^{Nbit-1}, where `Nbit` is the number of bits of the ADC.

CHANNEL_TRIGGER `option`

As for the EXTERNAL_TRIGGER, this command decides how the channel self-triggers generated on the threshold crossing are used. The 8 self triggers (one per channel or group) are masked and then ORed in order to generate a common trigger. NOTE: channel self-triggers are not available on x742 Model. For this purpose you may use the TR inputs.

There are three options:

`ACQUISITION_ONLY`: the self-trigger causes the acquisition of one event in all the channels of the board, regardless the channel(s) that generated it.

`ACQUISITION_AND_TRGOUT`: the same as before but, in addition, the common trigger is also propagated to the TRG-OUT (or GPO for the Desktop and NIM versions) connector.

`DISABLED`: the self-trigger of the relevant channel is ignored.

It establishes the function of one channel (or group in the case of x740) in auto-trigger. If `DISABLED`, the auto-trigger of that channel is ignored; if `ACQUISITION_ONLY` is set, the channel or group participates to auto-triggered acquisition, and, as the channel (or channel in the group) crosses the programmed threshold (upward or downward) all channels are triggered and an event is stored in memory. If `ACQUISITION_AND_TRGOUT` is set, auto-trigger logic, in addition to generating the trigger for the acquisition, produces an output pulse on the TRG-OUT (GPO in the case of Desktop and NIM) of the card.

GROUP_TRG_ENABLE_MASK `mask`

Hexadecimal number ranging from `0` to `FF`. This command is meaningful only for the x740 series (in other cases is ignored). It allows to determine which channels in the group of 8 participate to the auto-trigger. With x740 series, the auto-trigger is actually the OR of the non masked channels in the group. NOTE: unused channels must be disabled as a channel above the threshold, keeps the output of the OR always active and prevents other channels from generating the trigger.

Individual Settings for x742 Fast Trigger channels

The settings explained in this section are only for x742 models, where Fast Trigger channels (TR0 and TR1) are available. NOTE: remember that signal TR0 is the Fast Trigger for groups 0 and 1, while signal TR1 is the Fast Trigger for groups 2 and 3.

DC_OFFSET `value`

Where value is DAC setting that indicates the DC offset of the Fast Trigger channel; value ranges from `0` to `65535`.

Setting DC_OFFSET to `0`, the dynamics of the signal will be from -FSR to 0 (completely negative signal), setting to `65535`, the dynamics ranges from 0 to FSR (completely positive signal).

TRIGGER_THRESHOLD `value`

Where value is DAC setting that indicates the comparison level of the Fast Trigger channel; value ranges from `0` to `65535`.

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